THREE DIMENSIONAL INTERACTIVE DISPLAY

CROSS REFERENCES TO RELATED APPLICATIONS

This application claims the benefit of priority under 35 U.S.C. § 119(e) to U.S. Provisional application serial no. 60/191,472 filed March 23,2000.

ORIGIN OF INVENTION

The inventor of the invention described herein is an employee of the United States Government. Therefore, the invention may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

TECHNICAL FIELD OF THE INVENTION

This invention generally relates to data input devices and more particularly to an apparatus, for a manual input device manually providing three dimensional input to a computer.

DESCRIPTION OF RELATED ART

U.S. Patent No. 5,373,245 ('245) entitled "Capaciflector Camera" to John M. Vranish, which is incorporated herein by reference, teaches a capacitive type proximity sensor having an improved range and sensitivity between the sensor surface and an intruding object in the vicinity of that surface. The capaciflector camera described therein includes sensors and a shield that are strips of conductive material with an insulator coating. These strips of conductor material are such that the capaciflector camera can measure a field induced at a range of approximately 33 feet. The sensors may be arranged in a basket weave arrangement and are each connected to an operational amplifier and resistor for sensing signal. The capaciflector camera is used, primarily, for robotics in berthing and docking during robotic construction assembly and maintenance, especially in outer space and also for imaging and navigation for planetary rover robots.

U.S. Patent No. 5, 515,001 entitled "Current-Measuring Operational Amplifier Circuits" to John M. Vranish, incorporated herein by reference, teaches an operational amplifier (op amp) connected in series with a load and a current measuring impedance that may be used in with the Vranish capaciflector camera.

U.S. Patent No. 5,726,581 entitled "Three-D Capaciflector" to John M. Vranish incorporated herein by reference, teaches a capacitive type proximity sensor with improved range and sensitivity. The 3-D capaciflector senses the relationship between a surface of an arbitrary shape and an intruding object in the vicinity of the surface. The 3-D capaciflector camera is a non-planar capaciflector camera, provided in an example as a tubular shaped capaciflector camera.

The above described capaciflector camera is positioned to three-dimensionally locate objects with respect to other objects, in particular in an open space for robotic arm moving to position a workpiece with respect to a second workpiece to which the first workpiece is to be attached. In particular, the capaciflector camera sensors were described as being placed on or near mounting pins, latches and holes, thereby providing

information at or near points of contact between the particular work pieces being mated to achieve improved precision and simplify such work. Thus, the capaciflector camera positioned on the workpiece aides in navigating and docking of the second workpiece with the first by maintaining the 2 or 3-D positional relationship of the second workpiece with the first workpiece upon which the capaciflector camera is mounted. Sensor signals from the op amps are digitized and passed to a computer which calculates the relative positions of the two objects, (workpieces). Thus, the capaciflector camera provides a powerful computer input device for manufacturing, assembly and robotics.

Well-known manual input devices for computers include keyboards, a mouse, a track ball, touch pads, joysticks and among others. Voice entry is also becoming increasing in importance. However, all of these manual input devices are relatively disconnected from the response to the input that is being displayed by the computer. Digital signatures for example, are input, typically, with a stylus on some type of a touch pad and, the result is displayed on a display screen. The touch pad may be several feet from the display screen. Thus, it often may not be immediately apparent whether the computer response to the manual input accurately reflects or inaccurately reflects the intended input.

Thus there is a need for improved manual input/digital response (display) correlation paralleling hand to eye coordination for computer systems.

SUMMARY OF THE INVENTION

It is a purpose of the present invention is to improve manual input to displayed response coordination.

The present invention is a three-dimensional (3-D) interactive display system, display and method of forming thereof. A transparent capaciflector (TC) camera is formed on a transparent shield layer on the screen surface. A first dielectric layer is formed on the shield layer. A first wire layer is formed on the first dielectric layer, wires

on the first wire layer run in a first direction. A second dielectric layer is formed on the first wire layer. A second wire layer is formed on the second dielectric layer, wires on said second wire layer are orthogonal to wires on the first wire layer. The TC camera is protected by a surface dielectric layer. Wires on the first wire layer and second wire layer are grouped into groups of parallel wires with a turnaround at one end of each said group and a sensor pad at the opposite end. Each group of parallel wires includes five silver wires spaced a half a centimeter apart. The transparent shield layer is a 25 μm thick layer of conductive glass with a shield pad at one side. Vias, filled with silver epoxy, provide contact to each of the sensor or shield pads. An operational amplifier connected to each of the sensor pads and the shield pad biases the pads and receives a signal from connected sensor pads in response to intrusion of a probe. The signal is proportional to probe positional location with respect to the monitor screen. The operational amplifiers are driven from a common oscillator. In alternate embodiments the wire groups may be replaced with rows and/or columns of capaciflective pixels formed from 25 μm thick conductive glass plates, each row/column of pixels being connected together by a single wire to a sensor pad.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description. Furthermore, all the mathematic expressions are used as a short hand to express the inventive ideas clearly and are not limitative of the claimed invention.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Figure 1 shows a (3-D) Interactive Display System according to the present invention;

Figure 2 shows a top assembly view of the preferred embodiment TC camera and display;

Figure 3 shows an example of the preferred embodiment X grid and Y grid row/column sensor arrangement;

Figure 4 shows a cross section of the preferred embodiment TC camera of the present invention;

Figure 5 shows a plan view of an alternate embodiment 3-D interactive TC camera;

Figure 6 is blowup of a pixel area in Figure 5, showing four adjacent pixels;

Figure 7 shows another alternate embodiment TC camera which has a basket weave type receptor field;

Figure 8 shows another alternate embodiment TC camera wherein width of column pixels is different than the width of row pixels;

Figure 9 shows yet another alternate embodiment TC Camera wherein the row pixels overlap each other in 2 layers each;

Figure 10 shows another alternate embodiment TC Camera wherein column or row pixels are triangularly-shaped to alternate herring bone rows and columns;

Figures 11A-B are flow diagrams showing the steps to effect a basic cursor movement while in a word processing program;

Figures 12A-F shows 3-D Interactive Display software-reconfigured into several different input devices.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Turning now to the drawings and more particularly, Figure 1 shows a three dimensional (3-D) Interactive Display System 100 according to the present invention. An operator probe 102 is shown directed at a 3D interactive display 104. The probe 102 may be a stylus, a finger, a point on a hand or any other appropriate object. The type and shape of the probe 102 may be selected as appropriate for the particular application being executed and displayed and for the desired computer response.

The display 104 of the present invention includes a transparent capacitor (TC) camera 110 (represented as a grid) covering the face of a computer monitor. In addition to the display 104, the computer monitor includes interface circuits (not shown) connecting both the TC Camera 110 and the monitor to a computer 106. Accordingly, a computer-driven signal processor (not shown) is included to interpret signals from the TC camera 110 and provide interpreted signal results to the computer 106 which, in turn, interprets how the monitor image should reflect the proper response (represented by cross-hair 108) to the most current information from the TC camera 110. The computer 106 is programmed to generate monitor images and behavior rules of engagement for received TC camera 110 image data. An operator observes display responses to previous actions, i.e., to probe 102 movements reflected on the display 104. As referred to herein, pixel refers to an intersection of a row and a column, whether inhabited by orthogonal rows and columns of wires or by transparent conductive glass plates as described for alternate embodiments hereinbelow.

Figure 2 shows a top assembly view of the preferred embodiment TC camera 110 and display 104. The sensor array 110 is disposed in the center and covers the entire viewing screen surface of the computer display 104. An X-grid 112 and a Y-grid 114 are each disposed orthogonally on the display surface, i.e., X-grid 112 over Y-grid 114 or vice versa. Sensor pads 116 are located on at least two sides of the sensor array, passing signals from the X-grid 112 and Y-grid 114 to connected signal amplifiers (not shown) such as described, for example, in U.S. Patent No. 5,515,001 entitled "Current-Measuring

Operational Amplifier Circuits" to J.M. Vranish, incorporated herein by reference. Ground pad connections 117 are located on corners of the assembly. A shield layer 118 is disposed on the display surface beneath the X-grid 112 and Y-grid 114 and extends around the perimeter of the sensor array and attached sensor pads 116. A shield pad 120 is provided on at least one side of the shield 118. The shield 118 is activated with an identical potential (frequency, phase and magnitude) thereby projecting electric fields generated by the grids 112, 114 away from the display surface.

Figure 3 shows an expanded example of the preferred embodiment X-grid 112 and Y-grid 114 row/column sensors 130. The sensor grids 130 each include groups 132 of parallel wires 134. Each group 132 is connected to a sensor pad 102 in a corresponding row or column. An operational amplifier (not shown) is connected to each sensor pad 102. A turnaround 136 is disposed at the end opposite the sensor pad 102 of each wire group 132. The turnarounds 136 provide redundancy, for example, compensating for broken or open lines 134. Each group 132 of wires 134 includes multiple (>2) very fine wires, 5 in this example. The wires are thin enough that the grids are essentially invisible or, at the very least, they are not noticeably apparent. Preferably, the wires are .001" (25 μm) thick by .002" (50 μm) wide, silver wires and spaced 0.2 inches (0.5 cm) apart, extending the entire length/width of the display screen.

Figure 4 shows a cross section of the preferred embodiment transparent capaciflective camera of the present invention of Fig. 2 through 4-4. First, a 96% transparent shield film of Indium Tin Oxide, Tin Oxide or another suitable material, 1,000 ohms per square (Ω /SQ), is formed on the base surface 142. Preferably, the shield film is a 0.001 inch (25 μm) thick layer of conductive glass 140 which is transparent at this thickness, and is formed, for example, on the glass face of a cathode ray tube (CRT) or computer monitor screen. Next, a shielding pad layer 144 is deposited and patterned on the transparent layer 140. The shielding pad layer 144 is, preferably a 0.010 inch (250 μm) thick copper layer and may be deposited using any well known photo lithographic process, such as a liftoff type metalization process. Next a first transparent insulator layer 146 is deposited on the entire surface of the shield. Preferably the first transparent

insulator layer 146 is 0.001 inches (25 μm) thick. Next, the first grid wire layer 148 is formed. The first grid wire layer 148 is formed, preferably, using a silver paste material to form wiring patterns on the surface of the first transparent insulator layer 146 and, then, firing the surface at a suitable temperature to form the wires from the paste patterns. Such methods are well known in the art. Next, a second transparent insulating layer 150, identical to the first 146, is formed on the first grid layer 148. A second grid layer 152 is formed on the surface of the second transparent layer 150 identically and orthogonally to the first grid layer 148. Sensor pads 116 and sensor turnaround patterns 136 included in each layer 148, 152 during formation of both. A final transparent surface passivation layer 154 is formed on the second grid layer 152. The surface passivation 152 is formed of material identical to that used for the first and second transparent insulating layers 146, 150. Then, vias 156, 158 are opened down from the surface passivation layer to each of the sensor pads and to the shield pad. The open vias 156, 158 are filled with silver epoxy which provides a conductive contact to pads in each of the respective layers.

Thus, the present invention is a TC camera 110 that is a hands-free non-contact, 3D manual input device, 3D interactive system including the TC camera 110 and a method of forming the input device and system. According to the preferred embodiment of the present invention, a TC camera 110 is disposed on the face of a computer display 104. The TC camera 110 senses position, movement and direction of movement of a probe 102 disposed in front of the screen. Sensed probe signal information is passed to a connected computer 106 which, in turn, interprets the sensed information, formulates a response and reacts (displays the programmed response) to the probe 102 accordingly.

Driver circuits for capaciflector cameras are well known in the art and may be easily adapted for use with the preferred embodiment. Each voltage-follower includes a resistor in its feedback loop configuring it as a Current-Measuring Voltage Follower as described in U.S. Patent No. 5,515,001 entitled “Current-Measuring Operational Amplifier Circuits” to John M. Vranish, incorporated herein by reference. Typically one such Current Measuring Voltage Follower is connected to a sensor pad 158 or the shield pad 156 and driver by a common oscillator frequency. Thus, the system performs as a